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Implementation of a block-oriented model library for undergraduate process control courses in EMSO simulator

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A B S T R A C T

Process control courses usually have a section of the course focused on the building of block diagrams for modeling, simulation, and analysis of open and closed loop processes. For this purpose, students are often oriented to build models using SIMULINK or XCOS because of the versatility of these powerful tools in the easy construction of mathematical models using the concept of block-oriented programming. In this paper we propose a model library built in the software EMSO that allows the user to create block diagrams for process control studies. EMSO is a powerful tool for process modeling, dynamic simulation and optimization, freely available for academic purpose. With the developed library, analysis of systems responses, even for complex processes, can be carried out and PID controller tuning tasks are made easier and less time-consuming to the students, allowing them to advance in the study of more complex control strategies such as ratio, cascade, override, feedforward, among others. Students valued the developed tool as a very useful and practical one to favor a control course learning process and between equivalent and advantageous tool when compared with SIMULINK and XCOS.

1. Introduction

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There are two basic approaches to program mathematical models: (1) under a software-oriented programming or (2) under a block-oriented programming (Smith and Corripio, 2006). The first approach deals with the building of code-based algorithms that use specific syntax rules depending on the programming language used (e.g. MATLAB® and SCILAB® scripts, C/C++ code, etc.). Bogusch and Marquardt (1997) also subdivide this approach into equation-oriented and object-oriented modeling. The equation-oriented approach relies purely on mathematical rather than phenomena-based descriptions, making difficult to customize and reuse existing models, whereas in the object-oriented approach models are recursively decomposed into a hierarchy of sub-models, and aggregation and inheritance concepts are used to create new enhanced models based on previously defined models. On the other hand, the block-oriented programming offers the possibility of building models in a graphical fashion from basic built-in models or computing blocks, which are referred as basic math operators and basic functions. This approach allows the user to build, in an easy and graphical way, models just by clicking, dragging, dropping, and linking the basic built-in computing blocks (e.g. SIMULINK®, XCOS®), advantage that is desired for quick setup of exercises in a classroom.

Normally, in process control courses there is a section of the course focused on the building of block diagrams for modeling, simulation, and analysis of open- and closed-loop processes. For this purpose, students and teachers normally use SIMULINK® in MATLAB® because of the easy block

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diagram building process. However, these software products were not designed specifically for chemical process simulation and, consequently, much effort would be necessary by the students to build interesting examples involving, for instance, distillation columns, chemical reactors, heat exchangers, etc. On the other side, chemical process simulators do not provide many computing blocks available in SIMULINK and XCOS to help the students in their process control classes.

Several alternatives to the use of SIMULINK, with respect to block-oriented programming, are found in the literature. The best known freeware alternatives are XCOS in SCILAB, which uses block diagrams based on MODELICA models, and EMSO (Soares and Secchi, 2003). SCILAB is a computational tool inspired on MATLAB, but created under the concept of free software. The main characteristic of SCILAB which concerns to this work is how the model library of XCOS simulator, which looks like SIMULINK, is structured.

EMSO stands for Environment for Modeling, Simulation and Optimization and is freely available for academic purpose. Different from MATLAB and SCILAB, EMSO is a process simulator provided with libraries of equipment models and thermodynamic and fluid properties packages. This dynamic simulator has block-oriented and object-oriented modeling characteristics that can be used to build model libraries similar to the ones used in the SIMULINK and XCOS, in a very fast and efficient way. Fig. 1 shows the EMSO Graphical User Interface (EMSO GUI) and its main features. The EMSO object-oriented modeling language allows the user to develop models, estimate their parameters, and formulate optimization problems. All these tasks can be done following basic structures and syntax rules (Soares and Secchi, 2003; ALSOC Project, 2012; Rodrigues et al., 2009; Soares, 2007). This approach allows the user to create software-oriented models with EMSO.

However, there is also the possibility of building models for Process Flow Diagrams (PFD), in a graphical way, using the models of the EMSO Model Library (EML) palette, which is shown in Fig. 2. This allows the user to create block-oriented models by two ways: (1) using blocks already available in the EML, or (2) using blocks previously created by the user. Although the EML does not include among its models the basic blocks (basic math operators and basic functions) for block-oriented modeling, EMSO – that was primarily built under an Object-Oriented Programming (OOP) approach – has the required properties to build these blocks.

The block-oriented simulation tools include several model libraries that can be used in different engineering areas. Fig. 3 shows some screenshots with the main libraries included in the SIMULINK Library Browser and the XCOS Palette Browser. Although there are a lot of models in the aforesaid libraries, there is just a group of basic blocks that are used for accomplishing the main tasks in an undergraduate Process Control course. These blocks are summarized in Tables 1 and 2 for the case of SIMULINK and XCOS simulators, respectively.

The current configuration of the EML palette does not take into account the basic computing blocks for making

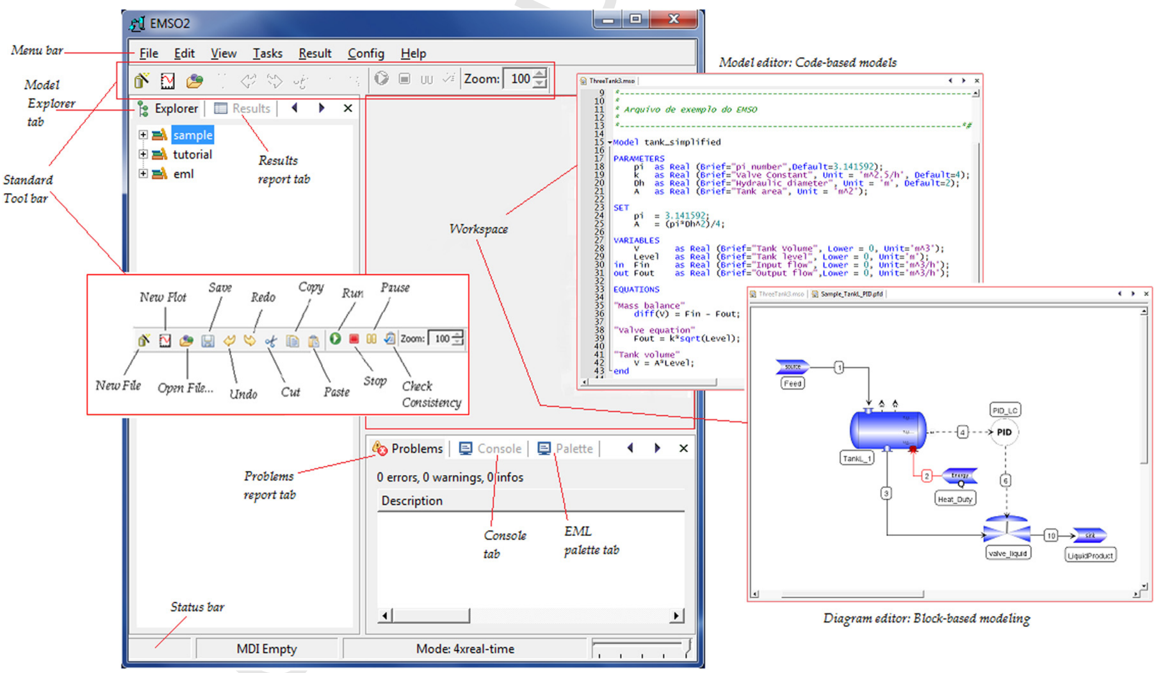

Fig. 1 – Graphical user interface of EMSO.

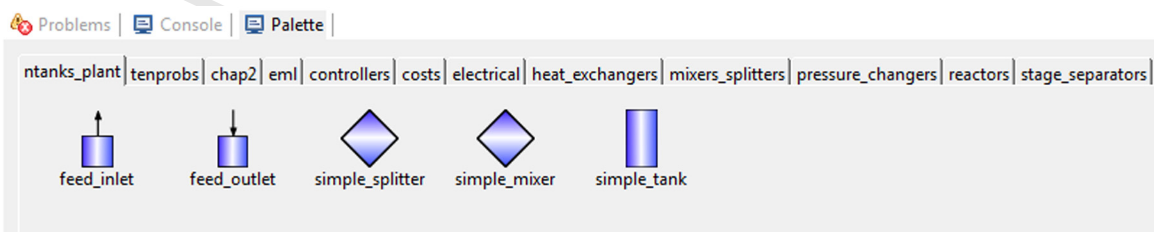

Fig. 2 – Palette of the EML.